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National PDES Testbed Report Series

Development Plan: Application Protocols for Mechanical Parts Production

NATIONAL PDES TESTBED

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National PDES Testbed

Development Plan: Application Protocols for Mechanical Parts Production

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July 2, 1991

Preface

This document describes the plan to develop a series of requirements and testing documents called candidate Application Protocols. An Application Protocol is a specific format for data which will be required by a STEP-based manufacturing cell. The Application Protocols for Mechanical Parts Production (APMPP) project is an integral part of an overall strategy for the National PDES[1] Testbed at the National Institute of Standards and Technology (NIST). The development of a STEP-based manufacturing cell is a companion project under the auspices of the National PDES Testbed. The Testbed was initiated in 1988 under the sponsorship of the U.S. Department of Defense Computer-aided Acquisition and Logistic Support (CALS) program. A major goal of the Testbed is to provide technical leadership in a national effort to implement a complete and useful specification for the exchange of product data. This specification must be designed to meet the needs of American industry and the CALS program.

The National PDES Testbed supports and actively participates in the international effort to develop the Standard for the Exchange of Product Model Data (STEP). The STEP development effort is led by the International Organization for Standardization (ISO) TC184/SC4. This document describes a plan to specify and validate a series of Application Protocols which will serve to resolve open issues within both international and national efforts.

This plan describes one of several technical project threads that have been established for the National PDES Testbed. Other threads address such areas as

- development of testing systems to validate the proposed standard,
- development of configuration management systems and services,
- construction of a prototype STEP-based manufacturing cell,
- establishment of a product data exchange network, and
- development of conformance testing systems.

The level of support provided for these technical threads and others will be determined by sponsor needs and a number of different priorities. As such, the development plan contained within this document outlines a reasonable schedule to accomplish the objectives of the thread. Changes in priorities and levels of support may either accelerate or delay the proposed schedule. This plan will be updated periodically to reflect technical changes in the project, current level of effort, and expected continued support.

Charles R. McLean
CALS PDES Project Manager
NIST

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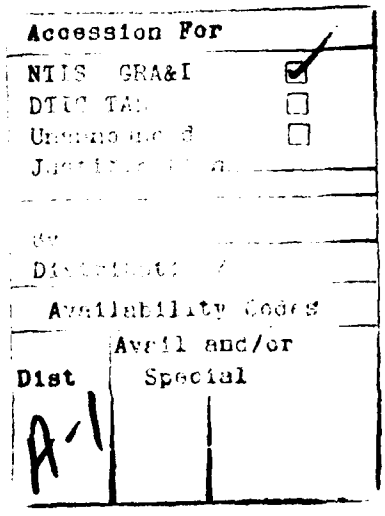
[1]Product Data Exchange using STEP (PDES) is the U.S. activity that is contributing to the development of STEP.

Contents



Executive Summary

The Standard for the Exchange of Product Model Data (STEP) is being developed as an international standard. Unlike some standards activities which may evolve from a set of existing implementations, Product Data Exchange using STEP (PDES) is an activity that will develop a set of concepts supporting future computer integrated design and manufacturing applications. The National PDES Testbed was established at NIST specifically to address the development and testing of STEP, and to serve U.S. industry in its use of the standard.

An Application Protocol (AP) is a specification for a subset of STEP data that can be implemented in an application system. The Application Protocols for Mechanical Parts Production effort will produce an early example of APs being used together in an operational prototype. This effort will develop, fully test, validate, and deliver a set of Application Protocols to the STEP Production Cell application systems which support the following engineering functions:

- detailed design,
- process planning, and
- numerical control programming.

The STEP Production Cell is an engineering and machining system capable of manufacturing mechanical parts from STEP product data.

The AP specifications provided will be implemented through the STEP Production Cell's application systems. In building the AP series, the APMPP project team will determine if STEP can actually support complete, unambiguous exchange of product data across several application system boundaries.

The STEP data used in the AP series will support the shared use of data rather than simple file transfer. Additional methods may be required to ensure that AP's with overlapping requirements can share product data. If additional methods are required, they will be developed and documented. The results of this effort will accelerate the development of the standard for product data.

This document describes the plan for developing and validating a series of three application protocols required as input to the STEP Production Cell. The resultant candidate APs, that will be submitted to ISO for inclusion in the standard, will have been validated and thoroughly tested prior to their submission.

A high-level breakdown of the tasks required to complete this effort, schedules, and a list of deliverables are provided. The final section of this document discusses staffing and equipment resource requirements.

1 Goals and Objectives

The primary goal of the Application Protocols for Mechanical Parts Production project is to develop candidate Application Protocols for submission to ISO for inclusion in STEP. A concurrent goal is that the Application Protocols developed support the requirements for the STEP Production Cell (SPC) project [FOW90]. Both of these efforts will take place within the National PDES Testbed [MCL90]. The STEP Production Cell will verify and demonstrate that a subset of the STEP specification is workable through production level tests. It will use the Detailed Design, Process Planning, and Numerical Control (NC) Programming AP's developed by the APMPP project as inputs. The AP's will specify the information requirements for the systems which will be implemented by the the SPC.

The AP's will adhere to the most current guidelines for technical content and format as defined by the Application Protocol methods project within the International Organization for Standardization (ISO). It is possible that the guidelines and formats for AP development may not be finished by ISO in time for use in the SPC. Should this prove to be true, the completion of the three initial AP's will not be delayed. The available guidelines will be incorporated into the processes used to develop the AP's required by the STEP Production Cell. Should these AP's require additional efforts to bring them into compliance with the final ISO guidelines, these revisions would take place following their delivery to the SPC. In fact, it is anticipated that the completion of the efforts outlined in this plan may speed the ISO process by providing a format for AP's that has been proven to be usable.

To achieve the objective of providing the STEP Production Cell with completed AP's meeting their scheduling requirements it will be necessary to pool personnel resources with outside organizations involved in AP development. Parts of existing candidate AP's created either solely by outside projects, such as PDES, Inc., an industry consortium, or jointly between the APMPP project and other AP developers may be used. APMPP team members will modify and extend these parts to support the specific requirements of the SPC. The AP series will incorporate existing work wherever the requirements are compatible.

The Detailed Design, Process Planning, and the Numerical Control Programming AP's will achieve their objectives if the AP series is capable of the following:

- sharing information between the component AP's,
- contributing to finalizing the AP methodology,
- being fully implemented by the manufacturing cell,
- finalizing conformance requirements, and
- supporting the SPC schedules.

The final goal of the APMPP effort is to provide AP's that can be tested through prototype systems within the STEP Production Cell. The use of AP's within the STEP Cell will add additional confidence to a validated AP by examining STEP efficiency, by proving that the AP can be implemented, and by demonstrating that the conformance requirements for implemented systems are reasonable and appropriate. The development and validation of these AP's and their implemention in the STEP manufacturing cell may provide the first example of an industrial application for the STEP AP's in a real world context.

2 Background Information

In the development of a new international standard new concepts and terms may need to be defined. This section provides background information that addresses the following areas:

- What is STEP?
- What is PDES?
- What is an Application Protocol?
- What is the structure of an Application Protocol?

2.1 What is STEP?

The Standard for the Exchange of Product Model Data (STEP) is being developed by the International Organization for Standardization (ISO) technical committee TC184 in order to provide a comprehensive and reliable data exchange mechanism to industry. STEP will support the unambiguous definition of product definition data throughout the product's life cycle. It will supply a neutral means for integrating computer-aided software systems allowing them to represent and transfer product data for the full life cycle of a product.

STEP consists of a set of information models that describe product definition data which could be used by multiple industries and application systems. The development of STEP uses information modeling methods to define the types of data within STEP and the rules which govern their use. Part of the specification describes how to format a data exchange file which abides by the definitions in the information models. The STEP architecture is constructed such that the application requirements are defined in separate documents called application protocols.

2.2 What is PDES?

Product Data Exchange using STEP (PDES) is the United States' organizational activity that supports the development and implementation of STEP. Much of this work takes place within the IGES/PDES Organization (IPO) [NCGA90] and PDES, Inc. PDES, Inc., a consortium made up of over twenty companies, is committed to accelerating the development of the standard. The National Institute of Standards and Technology (NIST) participates in PDES, Inc. as a government associate.

2.3 What is an Application Protocol?

Application Protocols are an important concept in the development of STEP [PAL90] since it is unlikely that there will be a single practical implementation of

the standard in its entirety due to its tremendous scope. An AP is a specification for interfacing with STEP in a standard way that provides the method for defining a subset of STEP that can be implemented for a particular application. It is the part of the standard that industry will be directly affected by, either through buying systems that implement the AP or from building application systems that meet the AP specification. An application protocol is like a recipe for building an application system that complies with STEP (Figure 1).

2.4 What is the structure of an Application Protocol?

There are a number of functional components that are needed to define an AP. Functionally, an AP will include the following:

- Scope - a clear definition of what is included in the AP,
- Application Reference Model (ARM) - a definition of the information requirements in terms familiar to an AP area expert,
- Application Interpreted Model (AIM) - a specification of standardized STEP data that matches the requirements described in the ARM,
- Validation Tests - a set of tests which are used to determine if the AP achieves the requirements defined in the ARM and the AIM, and
- Documentation - a description of how the information is to be used for exchange of product data.

The functional components of an AP are depicted graphically in Figure 2.

Figure 1. How is an Application Protocol Like a Recipe?

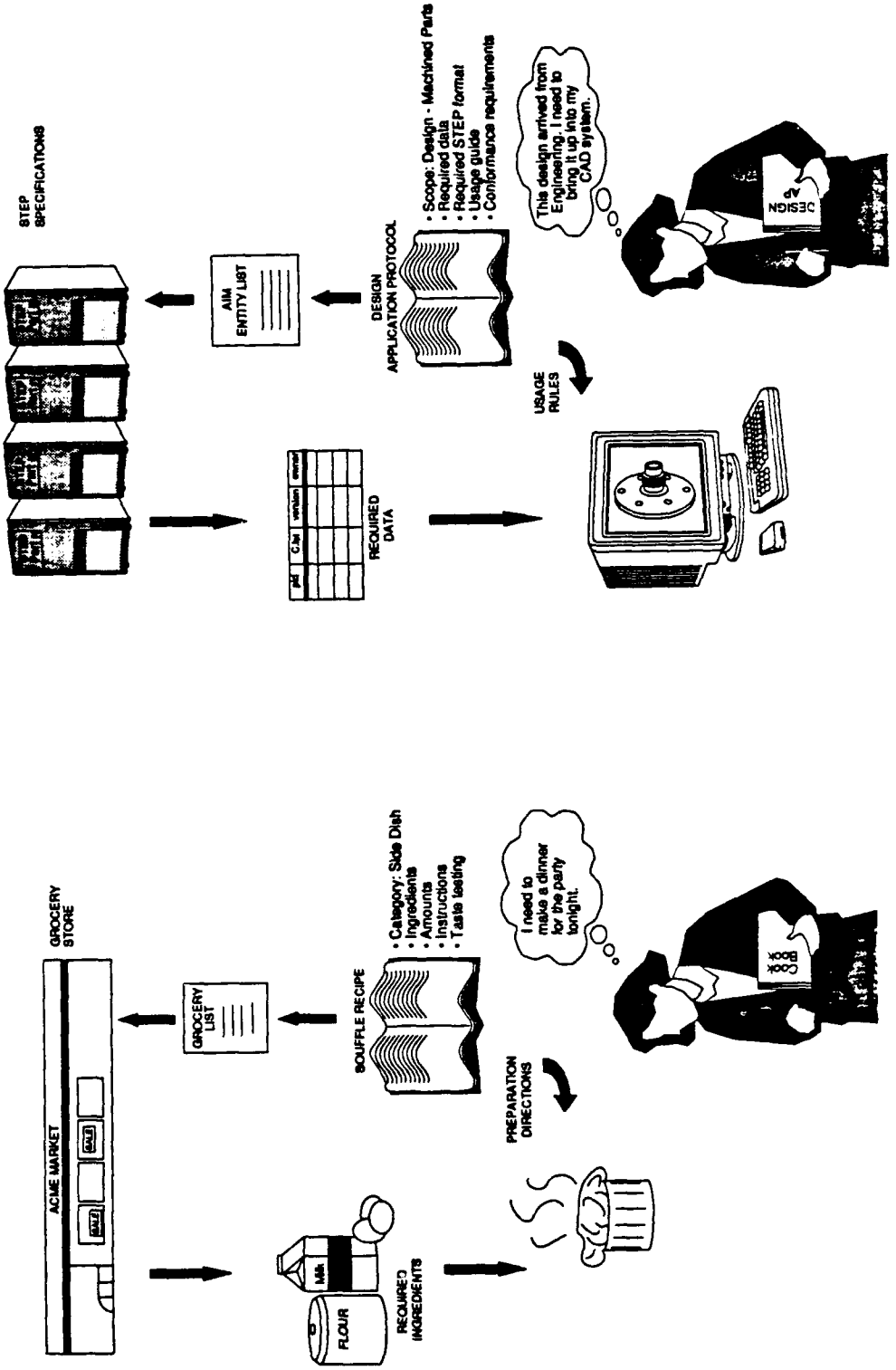
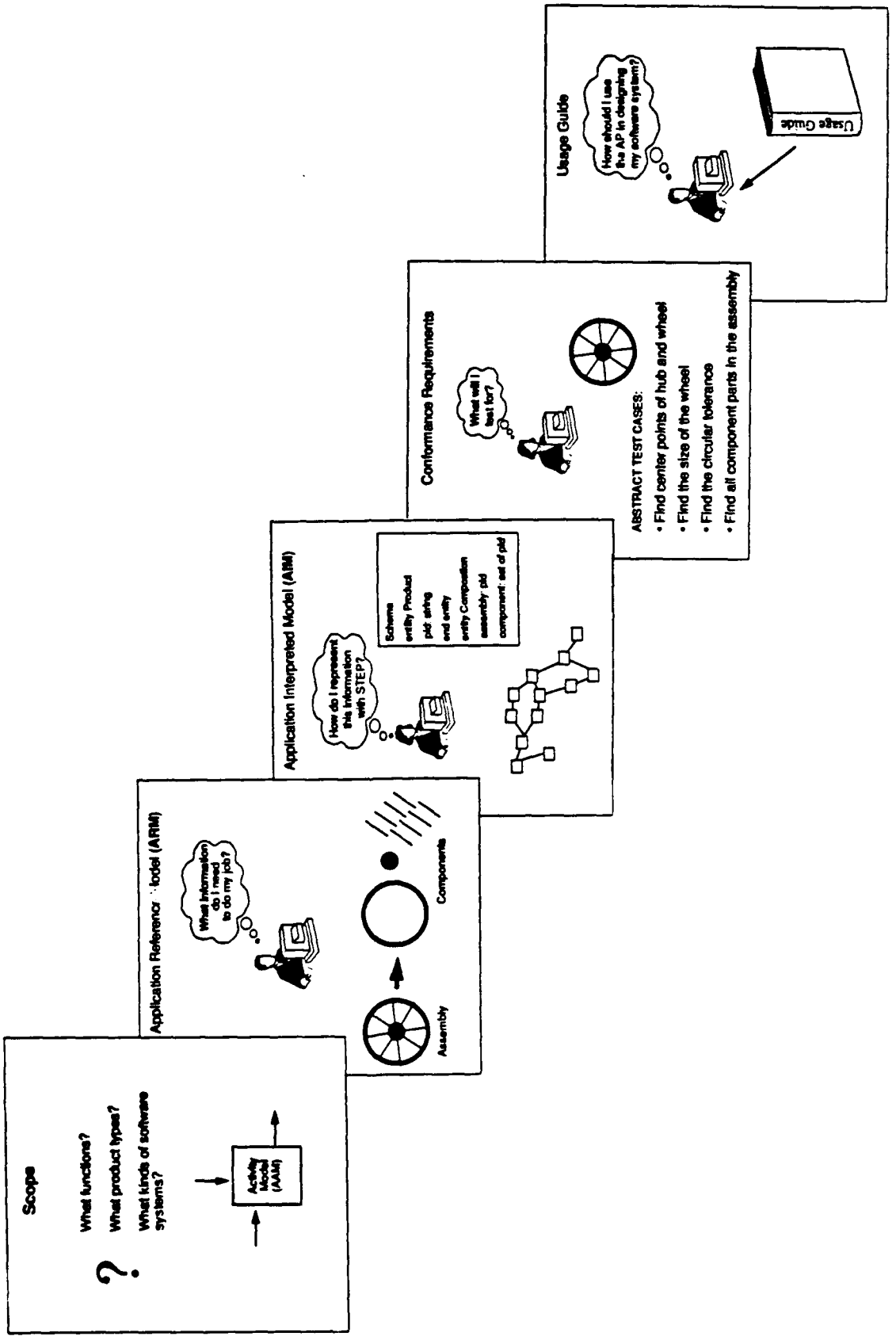


Figure 2. Functional Components of an Application Protocol



3 Project Overview

In order to meet the goals and objectives of the Application Protocols for Mechanical Parts Production plan, several factors must be considered. This section provides overview information that addresses the following areas:

- How is an Application Protocol developed?
- What issues are critical to Application Protocols?
- How will STEP data be shared across application system boundaries?
- What application functions will the Detailed Design AP support?
- What application functions will the Process Planning AP support?
- What application functions will the Numerical Control Programming AP support?

3.1 How is an Application Protocol developed?

The process of producing an AP includes five steps. These steps are

- developing the AP scope, context, and requirements,
- developing the Application Reference Model,
- developing the Application Interpreted Model,
- developing an AP Prototype, and
- developing and finalizing the Conformance Requirements.

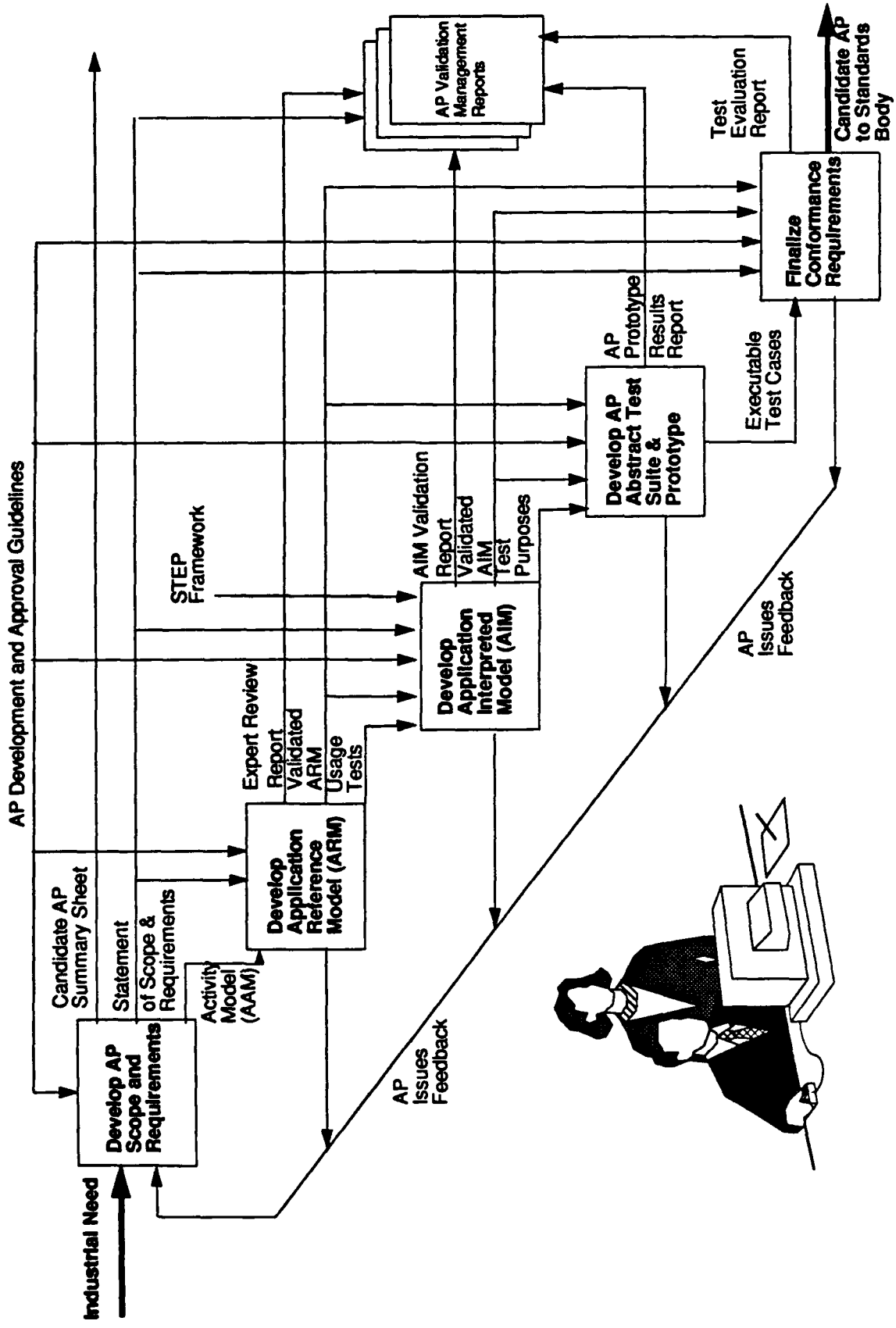
A summary process flow of these activities is found in Figure 3. Within each of the five steps the following efforts are repeated:

- develop the component,
- define its evaluation criteria, and
- validate the criteria to ensure the quality of the AP component.

The APMPP effort will rely on the information modeling and testing tools from the Validation Testing System [MIT90] to accomplish the AP validation activities.

The first stage of developing an AP is the definition of the scope, context, and requirements. The scope clearly describes the intended use of the application protocol. It includes a description of the operations to be performed by an application system within this context and how product data will be used to perform these operations. The result of the development effort is documented as an application activity model. The overall application requirements become the

Figure 3. AP Development Process



evaluation criteria for this and subsequent steps. The evaluation is performed by application experts (usually from industry) who review and approve these initial decisions.

The second stage is the development of an Application Reference Model (ARM). The ARM is a data model that documents the information needs, broken down to the level of detail needed by the operations within the application context. It includes all data elements used, and organizes them into entity definitions. In the ARM all information relationships are described in terms familiar to an expert in the application area.

Test purposes are developed to evaluate whether the ARM meets the requirements defined in the scope statement. These evaluation criteria are function tests that determine if enough information can be carried forward to make process decisions. The criteria is used to evaluate the completeness and correctness of the ARM's representation. The evaluation uses sample pieces of the test data to validate the ARM. An evaluation report is produced to describe the successful ARM validation. The validated ARM model and test purposes become the baseline from which the other parts of the application protocol are developed.

The Application Interpreted Model (AIM) translates and applies the general STEP standard for the application's use. The development of the AIM specification uses STEP entities that exist in the current version of the specification. The most appropriate STEP entity for representing a concept depicted in the ARM is selected for use in the AIM specification. The options for using the entities are restricted so that only one method is available for transferring each element of information from the ARM. Without this restriction data exchange would be ambiguous. A usage guide accompanies the AIM.

The evaluation criteria of the AIM evaluates the completeness and correctness of the AIM's representation of the AP information requirements as specified by the ARM. The objective of the AIM validation process is to ensure that no loss or change of meaning has occurred in the translation from the ARM to the AIM. This part of the AP model validation makes use of application area experts as well as experts in the capabilities and use of STEP.

The AP prototype development produces a simulation or prototype application system for the purpose of evaluating implementation concerns and executing the test using realistic data. Each test has evaluation criteria that identifies what the test purpose is, what information is used, how it is used, and the expected outcome of the test. The test specification is called an abstract test case. Each test is used to evaluate if the AIM representation is sufficient for the exchange of product data, either as an input to, or an output from, an application system.

The evaluation incorporates the use of realistic product data and software to execute the series of tests. The test results are captured, analyzed, and reported.

The conformance requirements and test purposes evaluation will analyze the completeness of coverage, correctness, and consistency of the test purposes with the ARM and AIM. The development and validation of a STEP AP is an iterative process that involves adding detail, translating application requirements into the STEP standard and ensuring that application systems can be implemented to comply with the AP. Each step in this process provides critical feedback for the next iteration of the AP.

3.2 Critical Issues Related To Application Protocols

There are several critical issues related to the APMPP effort. These issues will be tracked carefully throughout the project. Members of the APMPP team will contribute to their resolution through active participation in the ISO and IPO processes.

The existence of issues is not unusual in the early stages of the development of a new standard. Some issues should achieve resolution when the first AP from ISO is completed and approved. The effort described in this plan will address and resolve some issues which other AP efforts will not consider. Some of the open issues related to this AP series include the following:

- *Sharing Product Data Across AP Boundaries* - The issue with greatest impact to the SPC, and perhaps to STEP, is how AP's will communicate with each other. Are there additional parts of the AP method needed to ensure that this communication is possible? The first task in the APMPP effort is designed to address this issue.

- *Exchange versus Shared Use of STEP Data* - One of the requirements of the STEP Production Cell is that the STEP data will reside in a Level 3, or shared use environment. All AP candidates to date have specified a Level 1 environment, or data files being exchanged/passed from one to another. AP's are intended to be independent of the way in which the STEP data will be used. If AP's are to be independent of the way STEP is used, then a method for specifying the level of the data environment must be included. Should an AP be validated against both shared use and exchanged environments? Insights provided by the APMPP effort on this issue will benefit future AP development efforts.

- *Incomplete Methods and Procedures for Developing an AIM* - The methods and rules for developing an application interpreted model are not yet defined. Since the AIM is the portion of the AP that specifies the required STEP data, the rules for development must include procedures for ensuring that critical information represented in the AP's ARM (which defines the application requirements) are not lost in the translation to the AIM. Although alternative solutions have been proposed and are being analyzed, these procedures have yet to be firmly established.

- *Dependence on ISO for Development of AIM* - ISO's Working Group 4 (WG4), Qualification and Integration project is responsible for the overall technical consistency of STEP. As such, the current procedure for developing an application interpreted model requires that AP developers jointly build the AIM with WG4. Since the integration project within WG4 has the most current knowledge of the standardized STEP data structures that can be used to build an AIM, an APMPP team member must be allocated to work with WG4 to incorporate this information in the AP series AIM's.

- *What Makes a System STEP Compliant?* - The specifics of what it means for an application system to be STEP compliant are as of now largely undefined. Must an application system implement an entire AP or can it implement just a subset? This concern is directly related to the first issue (how AP's will communicate with each other.) The development of these AP's and their implementation within the STEP Production Cell will provide a working example of an application system utilizing STEP concepts.

- *Limited Guidance for AP Developers* - Limited published guidance is currently available to AP developers. Further definition is needed on the model validation process and how this relates to AP development, on AP issues, and on the AP development process. The APMPP and the SPC projects will provide invaluable information to the community at large in terms of concrete experience and lessons learned. This type of information will assist in resolving issues that can only be addressed by the implementation of a STEP based prototype.

- *How Will New Entities from AP's be Defined in STEP?* - When entities needed by a candidate AP are not included within any existing STEP part, a new model may need to be developed. Under the present system, application specific entities that are identified, but do not currently exist, are reviewed in an integration process to

determine if they should be added to the next version of STEP. In the case of developing APs for the SPC, the time necessary to develop and validate a new model will be unacceptable. The combined efforts of developing this series of AP's and their subsequent implementation in the STEP Production Cell can propose a method for adding entities that has been developed against an implementation effort.

In the event that the ISO has not finalized the functional aspects, technical components, and format for AP's to coincide with the SPC schedules, the APMPP development will conform with the most current guidelines. The Detailed Design, Process Planning, and Numerical Control candidate AP's developed for use by the SPC will be functionally and technically complete. Submission of these AP's into the standardization process could take place subsequent to their delivery to the SPC, once the guidelines are stable.

The ISO also maintains a list of issues that have been identified within that organization through their regular meetings. This list addresses items of concern in great detail, provides an explanation of the issue, and identifies the committee that has been assigned responsibility for resolving the issue. The APMPP effort will actively monitor specific issues and actively contribute to their resolution throughout the project, weighing the impact of issues and decisions on the delivery of usable, tested, and interoperable candidate AP's to the SPC.

3.3 Sharing STEP Data Across Application System Boundaries

The primary objective of STEP is support for the meaningful sharing of information across a broad range of applications. To share information, applications must have a related context. Support of this sharing by applications will be facilitated by the Application Protocols. In particular, the AP series for the SPC must be able to communicate and share STEP product data to satisfy overlapping information requirements between applications. The AP series will evaluate life-cycle support in STEP by cumulative development of product definition from design through manufacturing planning and through production.

3.4 The Detailed Design Application Protocol

An AP for detailed design addresses the use of a computer-aided design system for representing a completed design that is able to support downstream process planning and NC programming systems. This AP will encompass the representation of the nominal shape of a product, the dimensions of that shape, and the tolerance restrictions on those dimensions. Additional information such as the material from which the product is to be fabricated, the smoothness of

finished surfaces, and other data necessary for product engineering will also be addressed.

3.5 The Process Planning Application Protocol

An AP for process planning addresses the use of a process planning system to provide a detailed plan for the production of machined parts. This AP encompasses most, if not all, of the information required by the detailed design AP. The process planning AP will potentially require representations for specifying manufacturing features (e.g. holes, pockets, bosses, etc.) and the process plan itself.

3.6 The Numerical Control Programming Application Protocol

An AP for NC programming addresses information requirements for use of a NC programming system to develop control programs to drive manufacturing equipment. The NC programming system uses information from both the computer-aided design system and the process planning system to derive appropriate machine tool set-up and cutting instructions. The STEP representations needed by the NC programming system again include most, if not all, of those specified in the detailed design and process planning AP's.

4 Development Plan

The Application Protocols for Mechanical Parts Production development plan outlines the requirements necessary to produce the AP's for the STEP Production Cell. All of the tasks and functions described below are aimed at providing AP's to the SPC that are correct, usable, and in compliance with guidelines set by the ISO. This effort will employ a team of application area experts, persons knowledgeable in the evolution of STEP, and computer specialists qualified to define, develop, and test the resultant AP's. The primary deliverables will be the validated AP's themselves.

The development of AP's requires interaction with other organizations involved in the development and use of STEP. The APMPP project will work closely with the SPC effort as the two projects are highly dependent upon each other. External contact points include the ISO, IGES/PDES Organization (IPO), PDES, Inc., and other AP developers.

Differences may exist between the AP's that are developed as inputs to the SPC and those that are being submitted to the ISO as candidate AP's by other organizations. The AP's that support the SPC must fulfill real world requirements that will enable automation while providing product definitions that are consistent with the goals of the SPC. AP's that are submitted as candidates to the ISO, while meeting all requirements for technical correctness, may not address all concerns relating to real world systems. In order to satisfy the needs of the SPC, the AP's series must work within the constraints of the real world SPC system.

Task Descriptions

Three figures related to the tasks follow the task descriptions: Figure 4. APs for Mechanical Parts Production Work Breakdown Structure, Figure 5. Deliverables Table, and Figure 6. Project Schedule.

APMPP 0 Prepare APMPP Development Plan

The Development Plan provides the plan for the overall execution of the project. It includes the project goals and objectives, the project overview, task descriptions, and resource requirements for the effort. This document meets this deliverable.

APMPP 1 Develop Initial Framework to Identify AP Boundaries

This task will analyze how a broad area of activities should be broken down into APs. It will consider how many APs will be required to manufacture a complex product, what types of APs will be required, and how the APs will relate to each other. The development of a framework to identify AP boundaries will be useful to the STEP community as well as to the STEP Production Cell project.

APMPP 2 Define Required Product Life Cycle Subset for the SPC

This APMPP task will identify the portions of the product life cycle which will be supported by the STEP Production Cell. This task will describe the overall requirements to be satisfied by this series of AP's. The information shared among the AP's, and how the information sharing will occur will be specified.

APMPP 2.1 Develop Activity Model for the SPC

An activity model is used to represent the processes that will be demonstrated in the STEP Production Cell. The development of the APMPP Activity Model will include the definition of the steps, operations, and information groupings needed to create the AP's for the Cell. The model will depict how specific activities relate to each other.

APMPP 2.2 Define Requirements for SPC AP's

The high level information requirements for AP's have been defined in the Development Plan for the STEP Production Cell. This task will decompose the information groupings into specific information requirements for this AP series.

APMPP 2.3 Define Information Sharing Requirements within the SPC

This task will identify the information that will be shared among the various components of the STEP Cell. In order for the Cell to demonstrate AP usage in a production prototype setting, the information that will be shared between the AP's must be specified.

APMPP 2.4 Define the Requirements for STEP Shared Use

This task will specify the implementation methods used to enable the sharing of STEP product data within the SPC. Just as rules have been defined in English grammar to convey clear meanings through a shared vocabulary, rules for how STEP is to be used in a shared computing environment must be defined.

APMPP 3 Resolve the AP Format Used in the STEP Production Cell

This task will specify a format for the AP series used by the SPC. This format must support the requirements for shared use of STEP data, interoperability of AP's, and demonstrate that AP's can be implemented within the SPC. The experience gained from completing the tasks described in this plan will accelerate the resolution of critical issues faced by AP developers. The AP series developed for the SPC will test the AP guidelines for these purposes.

The elements included in this task will identify the current status of the AP guidelines and identify what is needed to provide and implement a completed format for this set of requirements.

APMPP 4 Identify the AP Development Strategy for the STEP Production Cell

In this task, a strategy will be defined for building and validating the AP series for the SPC that will optimize the development efforts of the APMPP teams. The ISO proposals for AP development and PDES, Inc. activities call for the delivery of a few candidate AP application reference models that are likely to contribute to the SPC AP series by the beginning of 1991. This activity will perform a high level assessment of this work and coordinate with these AP developers to allow for as much reuse of these efforts as possible.

APMPP 5 Develop and Validate Detailed Design AP

This task will define what will be covered in the Detailed Design AP. An application reference model (ARM) will be developed that formally describes the information requirements and constraints in the application specific terminology familiar to an expert from this area. From this an application interpreted model (AIM) will be constructed that describes the standardized STEP data constructs

required to support the requirements in the reference model. A set of validation tests will be defined that will be used to determine if the AP achieves the requirements defined for it. From this, an executable set of tests will be developed and used to validate the AP.

APMPP 6 Develop and Validate Process Planning AP

This task will define what will be covered in the Process Planning AP. An ARM will be developed that formally describes the information requirements and constraints in the application specific terminology familiar to an expert from this area. From this an AIM will be constructed that describes the standardized STEP data constructs required to support the requirements in the reference model. A set of validation tests will be defined that will be used to determine if the AP achieves the requirements defined for it. From this, an executable set of tests will be developed and used to validate the AP.

APMPP 7 Develop and Validate Numerical Control Programming AP

This task will define what will be covered in the Numerical Control Programming AP. An ARM will be developed that formally describes the information requirements and constraints in the application specific terminology familiar to an expert from this area. From this an AIM will be constructed that describes the standardized STEP data constructs required to support the requirements in the reference model. A set of validation tests will be defined that will be used to determine if the AP achieves the requirements defined for it. From this, an executable set of tests will be developed and used to validate the AP.

APMPP 8 Integrate Validated AP's

This task will ensure that the three AP's developed for the SPC will work together. Tests will be designed, implemented, and executed to confirm that information can be shared across the AP series. All discrepancies that may affect the integrity of the data will be resolved prior to the delivery of the AP's to the SPC.

APMPP 9 Prepare the AP's for Submission to ISO

When the AP format is finalized, the three AP's will be brought into compliance with the definition specified by ISO. This may require document formatting changes and repeating AIM development and validation for any STEP standardized constructs that may have changed because of a new version or release of STEP. Following the completion of any necessary changes, the candidate APs will be submitted to ISO through the appropriate channels.

Figure 4. APs for Mechanical Parts Production Work Breakdown Structure

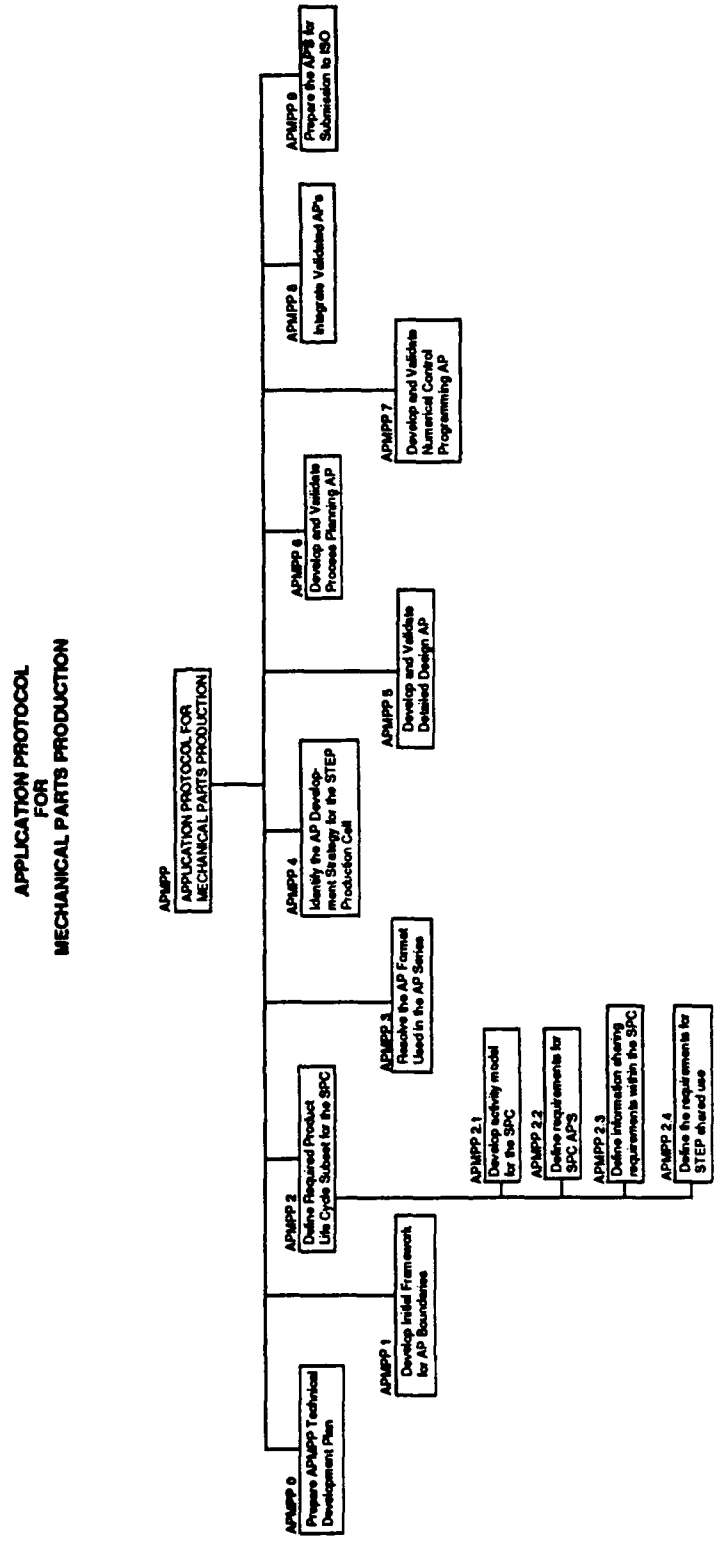
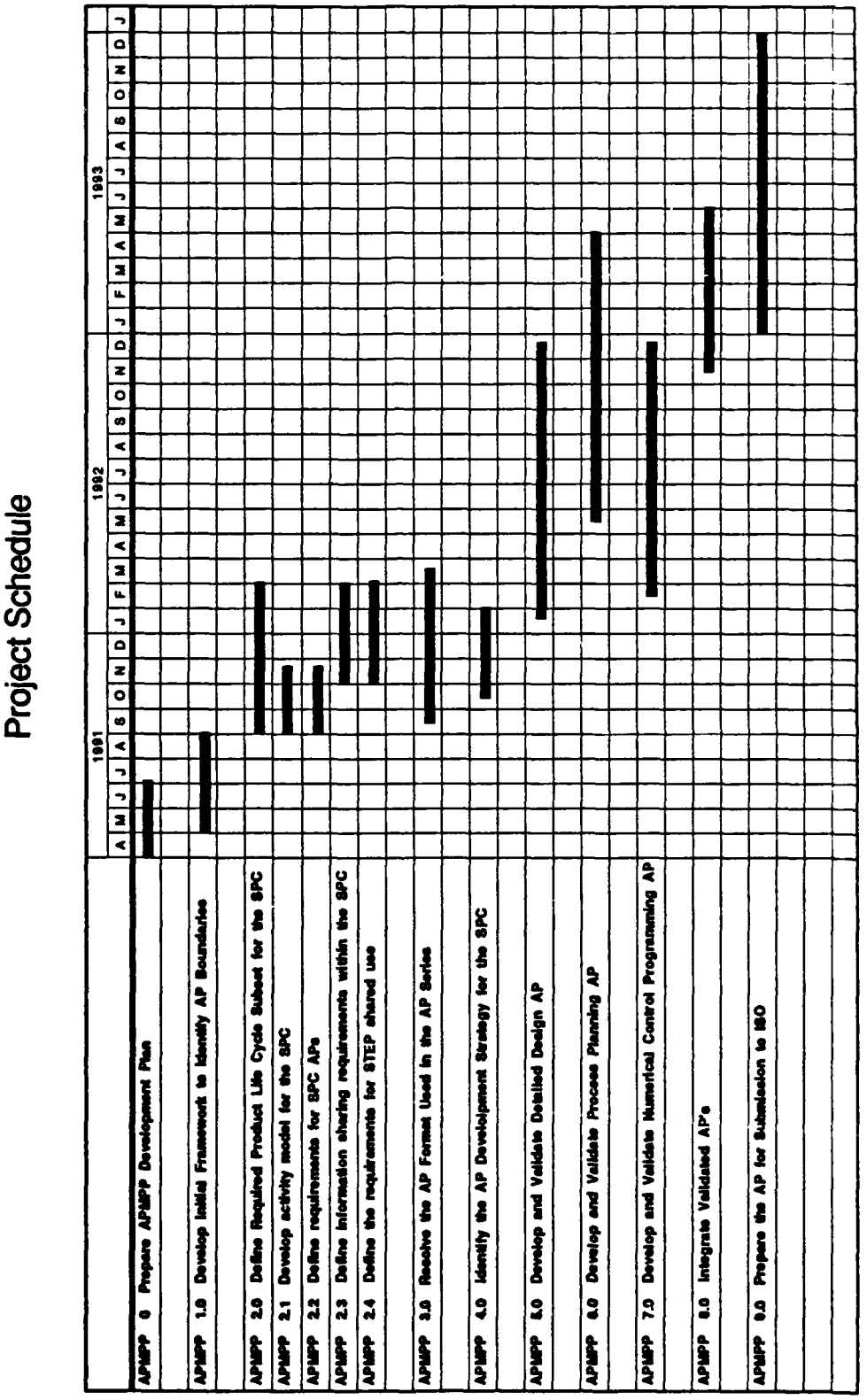


Figure 5. Deliverables Table

TASK	START	STOP	DELIVERABLE	SUPPLIER	CUSTOMER
APMPP0 Develop APMPP Specification Plan	4/91	6/91	Technical Development Plan	STC	CALS/ISO/APC/PDES, Inc.
APMPP1 Develop Framework for AP Boundaries	5/91	8/91	AP Framework Report	STC/APC	CALS/ISO/PDES, Inc.
APMPP2 Define Product Life Cycle for SPC	9/91	2/92	SPC Activity Model	STC/APC	CALS/ISO
			Data Planning Model	STC/APC	CALS/ISO
			Shared Info Requirements	STC/APC	CALS/ISO
			Guidlines for Shared Use	STC/APC	CALS/ISO
APMPP3 Resolve AP Format	9/91	3/92	AP Format Specification	STC	APC
APMPP4 Identify Strategy for Cell AP's	1/92	12/92	AP Strategy Document	STC	APC
APMPP5 Develop/Validate Detailed Design AP	5/92	4/93	Validated Detailed Design AP	SPC	APC
APMPP6 Develop/Validate Process Planning AP	3/91	3/92	Validated Pocess Planning AP	SPC	APC
APMPP7 Develop/Validate NC Programming AP	2/92	12/92	Validated NC Programming AP	SPC	APC
APMPP8 Integrate Validated AP's	11/92	5/93	STEP Shared Data:Lessons Learned	SPC	CALS/ISO/PDES, Inc.
			Integration report	SPC	APC
APMPP9 Prepare AP's for ISO Submission	1/93	11/93	ISO Compliant Detailed Design AP	SPC	CALS/ISO/PDES, Inc.
			ISO Compliant Process Planning AP	SPC	CALS/ISO/PDES, Inc.
			ISO Compliant NC Programming AP	SPC	CALS/ISO/PDES, Inc.

Figure 6. Project Schedule



5 Resources

5.1 Personnel

The following combination of skills are required for the application protocol development teams. A team will be assigned to work on each of the three application protocols that will be developed for the STEP Production Cell. This resource projection was used in developing the schedule. The staffing needs will be filled by drawing upon subject experts from both NIST's Factory Automation Systems Division and other CALS partners. It is assumed that resources from the Application Prototype Center can be dedicated to the initial tasks and used until the first application protocol is delivered. The STEP Integration Expert and Application Protocol Expert will be the most difficult positions to staff but are required to reduce the effort required to deliver the AP series.

The following project staff are required:

- Project Manager
- Lead Analyst (one per AP team)
- Information Modelling Specialists (two per AP team, minimum)
- Model Testing Specialists (two per AP team, possibly less while issues are being resolved)
- Validation Test System Operator (one, shared by the AP teams)
- Configuration Librarian (one, shared by the AP teams)
- Application/Subject Matter Experts (two per AP team, with an additional two on-demand for requirements and reviews)
- STEP Integration Expert (half-time, shared by the AP teams)
- Application Protocol Expert (half-time, shared by the AP teams)

In addition to these positions, part time assistance on an as-needed basis will be required from a Technical Editor and specialized support staff (for IGES verification, CAD workstation operator, etc.).

The personnel will be organized into teams which are responsible for delivering either the foundation Tasks (1, 2, 3, and 7), one of the AP series (Tasks 4, 5, and 6), or preparing the AP series for submission to ISO (Task 8). A core team will be responsible for the foundation tasks and requires the participation of the AP Project Manager, the SPC project manager, the STEP integration expert, and the application protocol expert. These individuals will also act as reviewers for the project. Teams will be formed for each of the Application Protocols for Mechanical Parts Production tasks and the team will include at least one member from the core team.

Project Manager

Responsible for the overall structure and planning for the APMPP effort. Develops work plans, defines tasks and builds and monitor schedules. Defines functions, roles, and skills required for tasks. Negotiates for staff resources and system resources. Coordinates with CALS partners, PDES, Inc., ISO working groups and the other National PDES Testbed Centers for subject experts, new or enhanced models, and test product definition data. Develops procedures for AP development. Experience in management of CIM projects and the STEP development methodologies. Possesses interpersonal, oral and written communication skills, as well as project planning, coordination, scheduling, monitoring, and review experience.

Lead Analyst

Provides technical leadership on a team responsible for developing an application protocol and coordinates the activities performed by the team. Works with the project manager to identify the type of subject experts needed and the timing of reviews. Leads the analysis of the functional requirements of the application and the development of the AP parts. Experience in conceptual modeling using both Express and IDEF or other semantic modeling methodology, and structured design techniques. Knowledge of the AP development process, the AP development and acceptance guidelines, the STEP model documentation guidelines, and the STEP part qualification requirements. Possesses leadership, interpersonal, written and oral communication skills.

Information Modeling Specialists

Performs the analysis of the application's functional requirements and the development of the scope and requirements, the application reference model, the application interpreted model, and the usage guidelines. Experience in conceptual modeling with both Express and IDEF, and structured design techniques. Possesses interpersonal, written and oral communication skills.

Information Model Testing Specialists

Develops the application protocol validation plans and procedures. Develops test purposes and abstract test cases. Prepares test data and builds executable test cases. Conducts analysis of test results along with subject experts and reviews results. Develops validation test reports and documents model issues. Recommends improvements in validation tools and techniques. Experience in CIM systems development and software or product testing. Possesses interpersonal, written and oral communication skills.

Validation Test System Operator

Executes validation test cases according to a validation plan. Assists in the preparation of test data. Captures and formats test results for analysis. Manages executable files and test data to facilitate re-testing of improved AP components. Experience with CAD systems, software testing, configuration control concepts, UNIX tools, and relational DBMS concepts.

Configuration Librarian

Maintains information models, test purposes and test cases, model issues, validation reports, and AP in the validation testing environment. Experience in CAD systems, software testing, configuration control concepts, and UNIX tools. Experience with configuration control software and document preparation packages.

Application/Subject Matter Experts

Responsible for identifying the application information requirements and for describing how the information is used during the scope and requirements and application reference model AP development steps. Responsible for technical review and analysis of validation results for the remaining AP development steps. Possesses a thorough understanding of the application area for which the application protocol is being developed, e. g. mechanical design, process planning or numeric control programming. Experts should be drawn from both the manufacturing engineering and CIM software development backgrounds. At least one expert must be knowledgeable in geometric representation techniques and one expert must have experience in developing detailed design with commercial CAD systems.

STEP Integration Expert

A functional expert in the STEP development processes, integration methods, and STEP framework who provides information relating to the status of STEP development activities within the standards making organizations (i.e., ISO, IPO). Possesses in depth knowledge of the STEP Generic Product Data Model (GPDM), the GPDM Parts which provide detailed general requirements, STEP integration methods, and an overall knowledge of the procedures and guidance directing the development of STEP.

Application Protocol Expert

A functional expert in the STEP application protocol development method. Provides information relating to the required format as currently defined for STEP

AP's and possesses up to date knowledge on the progress and status of AP issues and other emerging application protocols. Reviews the AP parts under development by the APMPP with supporting documentation, and validation reports for adequacy. Experience in performing AP validation, a knowledge of AP development methods, and a knowledge of the model qualification methods.

5.2 Commercial Software

The National PDES Testbed project has been successful at obtaining software donations. Relatively small expenditures are expected. Training and manual costs are expected to equal direct software expenditures.

- Project Planning and Scheduling Software
- CAD package with solids, feature-based, with IGES (loaned)
- CASE Tools (PC based, anticipate a donation)
- IGES verification software
- Document preparation
- Electronic mail system
- Software for configuration management
- Relational or object oriented database package and other packages as required by the Validation Testing System (loaned)

5.3 Equipment

A considerable amount of equipment exists in the National PDES Testbed, both from purchases and from equipment donations. The equipment described below either exists within the division or is expected to be provided by the Validation Testing System:

- Personal Computers, (3) low-end, for document development, (exist)
- Compute Server, (1) dedicated for dial-in computing,
- High-end POSIX Workstation, (1) with 1 gigabytes storage for validation activities,
- X Window terminals, (3) for validation and test case development, (could substitute low-end POSIX Workstations),
- SLIP protocol device, (1) shared with other validation teams, for remote X Window access,
- CAD/Graphical Workstation, (1) (exists, donated),
- Plotter, (1) long axis roll plotter (to be acquired) and (1) Post Script Printer, and
- High speed modem bank, (8) in-bound, (2) out-bound, (exist as shared resource, negotiated use).

5.4 Facilities

The laboratory and meeting spaces within the National PDES Testbed at NIST will be shared with other AP development activities. Some guest research staff from CALS partners are anticipated and they will require short term office space. These areas have been outfitted over the past year. There are only a few items which are still required:

- Validation testing user laboratory space for two testing teams (twelve seats), exists and is in use.
- Validation meeting space for modeling and testing teams (twelve seats), exists and is in use.
- Guest worker office space, at least two desks are required.
- Asynchronous communication lines for modem connections, 5 lines exists and are in use.
- Photocopier and FAX machine due to the distance between the laboratory facility and division support services.

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7 Glossary

Abstract Test Case

A logical expression, in human readable form, specifying a state that must exist to satisfy an application purpose. This specification provides a basis for developing machine executable tests.

Application

A specific function or work area that contributes to creating product definition data and/or finished product deliverables to meet an industrial need. The nature of an application depends on several factors, one of which is discipline, such as electrical, mechanical, etc.

Application Interpreted Model (AIM)

A conceptual data model that describes the STEP standardized data constructs required for functional equivalence to the application protocol's application reference model.

Application Protocol (AP)

A method which defines the context for the use of product data to achieve consistent and reliable exchange and which specifies this use to satisfy an industrial need.

Application Reference Model (ARM)

A conceptual data model that formally describes the information requirements, including structural requirements, and constraints for an application area. The model uses application specific terminology and rules familiar to an expert from the application area. The model should be independent of any physical implementation and must be validated by experts from the application area.

Conformance Requirements

A description of the conformance criteria and test purposes designed to verify if an implemented system complies with a standard.

Executable Test Case

A machine executable test which results from transforming an abstract test case into a computable form so that reproducible test results can be produced.

Scope and Requirements

A statement of application domain information needs that must be accommodated to achieve meaning and useful information exchange.

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The Standard for the Exchange of Product Model Data (STEP) is being developed as an international standard. The National PDES Testbed was established at NIST specifically to address the development and testing of STEP, and to serve U.S. industry in its use of the standard.

An Application Protocol (AP) is a specification for a subset of STEP data that can be implemented in an application system. The Application Protocols for Mechanical Parts Production effort will produce an early example of APs being used together in an operational prototype. This effort will develop, fully test, validate, and deliver a set of Application Protocols to the STEP Production Cell application systems which support the following: detailed design, process planning, and numerical control programming.

This document describes the plan for developing and validating a series of three application protocols required as input to the STEP Production Cell. The resultant candidate APs, that will be submitted to ISO for inclusion in the standard, will have been validated and thoroughly tested prior to their submission.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

Application Protocol; mechanical parts production; National PDES Testbed; PDES; STEP; STEP production cell; Validation Testing System

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